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DEVELOPMENT OF MODULAR MACHINE DESIGN AND TECHNOLOGIES OF DYNAMIC ACTION FOR FINISHING-GRINDING TREATMENT BY AN OSCILLATING ABRASIVE MEDIUM

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ABSTRACT

A complex approach is proposed to designing machines and technologies for finishing-grinding treatment of complex-shaped parts by an oscillating fine-dispersed abrasive medium. A designed element base has been developed for the design-technological synthesis of the autonomously controlled actuating mechanisms in the form of the device with the processed parts and the reservoir, combined into a single aggregate modular machine. The field of combining schemes of the power actions on an abrasive medium and processed parts has been considered.

Keywords: finishing-grinding treatment, abrasive medium, modular machines, design-technological synthesis, autonomous actuating mechanisms.

1. INTRODUCTION

Theoretical and experimental research on the development and creation of modular equipment and technology for finishing-grinding treatment by free abrasives under the influence of different actions are aimed at achieving high technological flexibility,

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universality and productivity. As a whole, this task is an actual scientific and practical problem of treatment of volume complex-shaped parts [1 – 6].

In this connection, one of primary tasks of mechanical and instrumental engineering in the competitive modern market of machinery and technologies is to produce a considerable reduction in time and labor input for the design, manufacture and introduction of new equipment with mechanization of the finishing-grinding operations providing, therefore, high operating indexes of the processed parts.

2. DIRECTIONS IN DESIGNING MODULAR MACHINES AND TECHNOLOGIES

The above mentioned considers the creation of a fundamentally new complex approach to the development of modern modular machines and technologies for finishing-grinding treatment. Such an approach consists of a project design-technological synthesis of actuating and autonomously controlled mechanisms in the form of the reservoir with abrasive medium and the device with the processed parts. When designing such actuators, taking into account their general operating purpose, they are selected from an element base and jointly operating at various schemes of the power action on the abrasive medium and the processed parts when they are placed in the fastened state into the reservoir of finishing-grinding machine [7-9].

At present, the equipment with power drives, utilizing the energy of vibrations in the vertical and horizontal planes, the centrifugal energy with the different variants of forces, as well as the energy of force of stream motion of fluid flow, have been developed on the basis of traditional mono-block constructions with the low level of unification [10, 11].

It is quite clear that, the transition of finishing-grinding equipment to a modular design, in which principles of the building-block design of mechanisms are utilized and schemes of the power action on abrasive medium and processed parts are combined, will demand a profound theoretical background of conceptual methods for forming the element base of actuating mechanisms. Thus, it is necessary to take into account the intensification of mechanics of circulation motion of oscillating abrasive medium and the features of its effect on the surfaces of the processed parts.

Theoretical studies of the motion of circulation flow of granular abrasive medium in the machine reservoir for finishing-grinding treatment had been already reported [3, 7]. The mathematical simulation was based on the physical phenomenon in which the oscillating abrasive medium passes in the quasi-liquid state or in the state of vibration boiling at the proper quantity of the reported energy. Then, the choice of simplified Navier-Stokes equations led to the expression of Bessel's functions and their integral transformations that allowed to base complicated cycloid-trochoidal nature of kinematics of the process on the operations of treatment by the oscillating abrasive medium.

In addition, it became possible to determine the velocities of the moving medium at any point of the reservoir, which is needed for the determination of the parameters of modular machines and technologies. The areas of machine's reservoir with high impulsive loading were also exposed when combining schemes of the power effect on the abrasive medium and the processed parts that created the rational conditions for forming the structure of a modular

machine from the autonomous actuating mechanisms of the reservoir and the device with processed parts [11, 12].

At the same time, the use of the aggregate-module principle for the development of modular machines for finishing-grinding treatment will permit the rational organization of their industrial production and exploitation, and, also, make it possible to simplify and accelerate conducting the necessary repairs.

The development of scientific-practical and methodological principles for designing modular machines possessing with increased efficiency and operating reliability, is based on the:

- creation of the element base of a project design-technological synthesis of actuating autonomously controlled mechanisms of modular machines, executing the operations of the required technological purpose;
- substantiation and complex choice of rational combinations of regime parameters for operating the power drives of actuators of modular machines with respect to granulation of fine-dispersed abrasive media, micro-section grain and different micro-section grinding powders, subject to the effect of the quasi-liquid state and vibration boiling. In addition, the conditions of adaptation of the kinematic and dynamic features of oscillating motion of these abrasive mediums, that affect the change in the physical-technological properties of the imperfect surface layer of the parts at their shape forming by micro-cutting and elastic-plastic deformation processes, must be taken into account.

3. STRUCTURE OF THE ELEMENT BASE OF PROJECT DESIGN-TECHNOLOGICAL SYNTHESIS

The proposed element base of project design-technological synthesis can correspond entirely to the principles of creation of methods for vibration treatment, functionally connected with the field of combining, both schemes of power actions and actuating mechanisms concerted, see Fig. 1.

The element base consists of mechanisms in the form of reservoirs, which have a different cross-sectional shape at various geometrical sizes, see Fig. 2, and mechanisms in the form of the devices with the processed parts fixed on them, see Fig. 3. In the process of operation, for reaching a certain technological result, the actuating mechanisms are structurally combined into a single modular machine's aggregate, which is the jointly functioning technological system made up of the reservoir with the abrasive medium and the device with the processed parts, see Fig. 4.

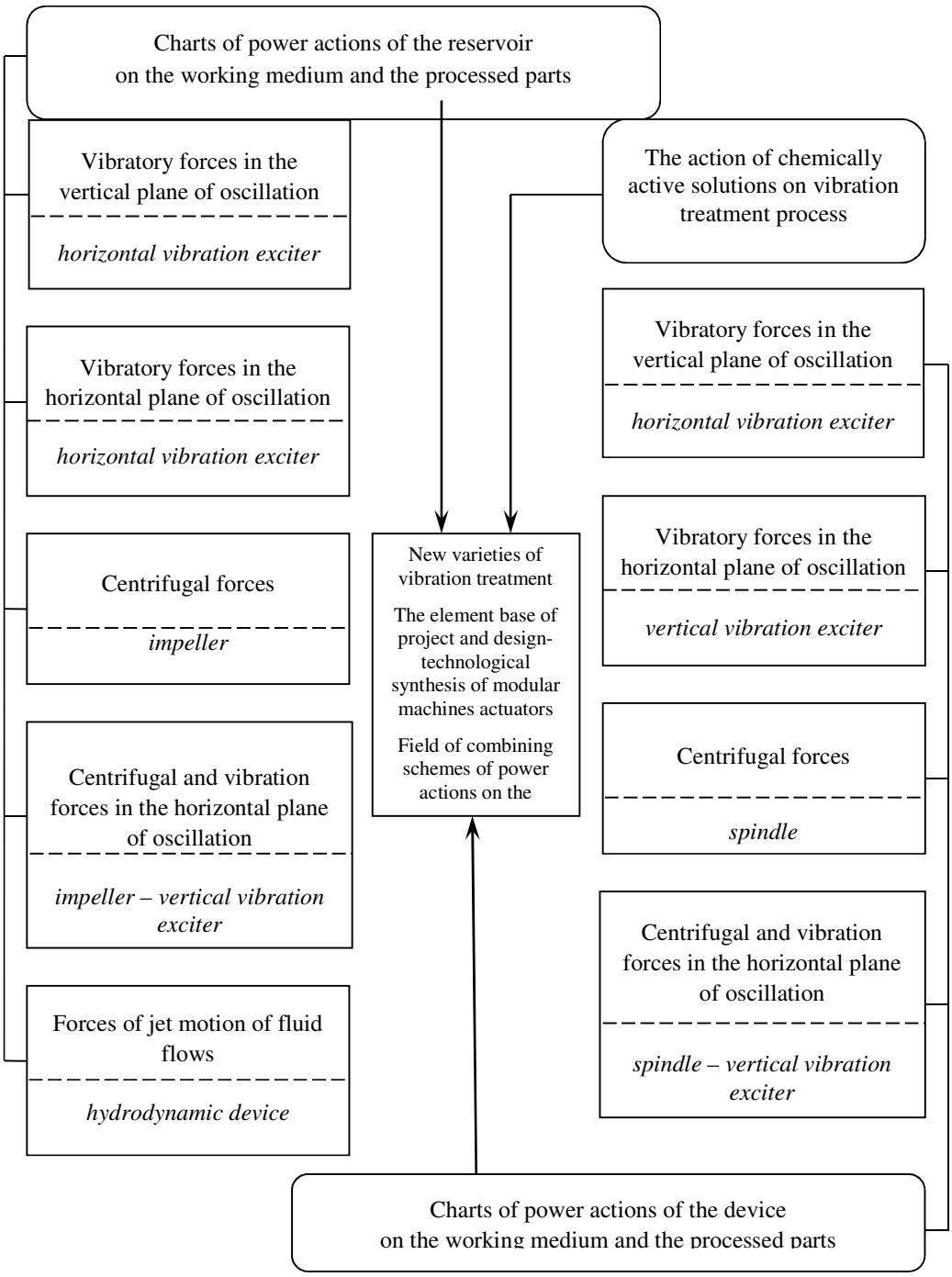
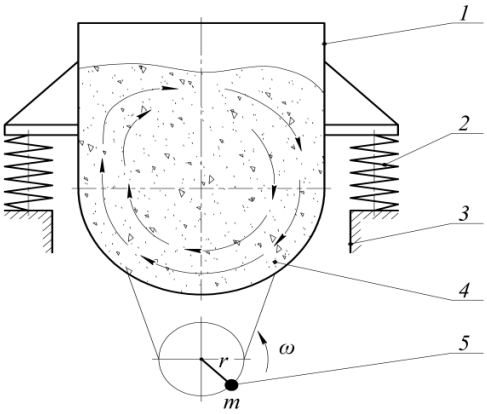
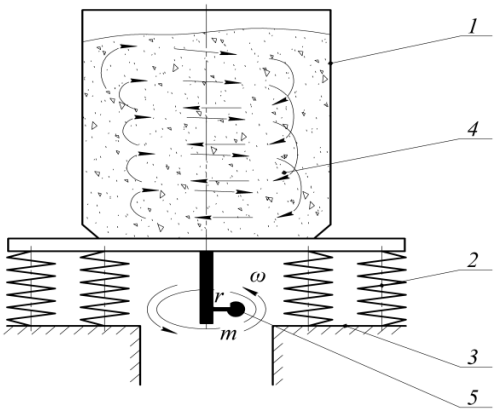


Fig. 1 The element base for the project design-technological synthesis of the concerted actuating mechanisms of modular machines and technologies for finishing-grinding treatment



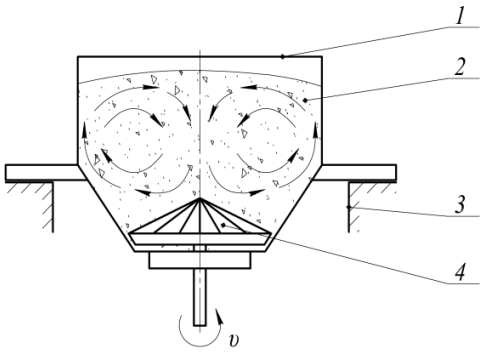
(a)

1 – reservoir, 2 – suspension,
3 – support, 4 – working medium,
5 – horizontal vibration exciter



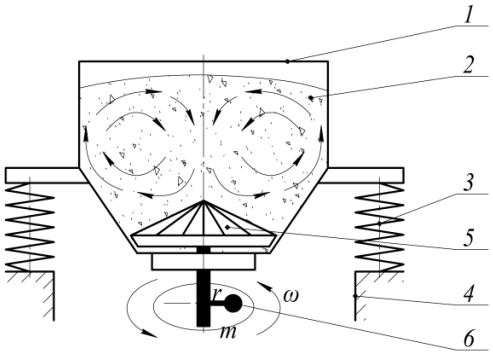
(b)

1 – reservoir, 2 – suspension,
3 – support, 4 – working medium,
5 – vertical vibration exciter



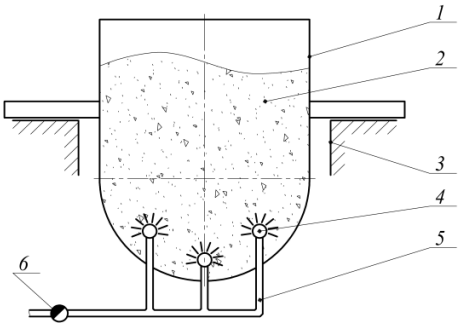
(c)

1 – reservoir, 2 – working medium,
3 – support, 4 – impeller



(d)

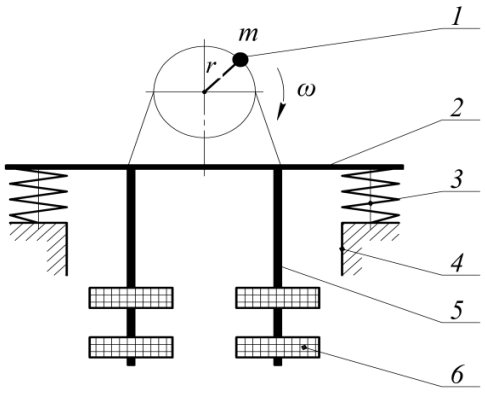
1 – reservoir, 2 – working medium,
3 – suspension, 4 – support,
5 – impeller, 6 – vertical vibration exciter



(e)

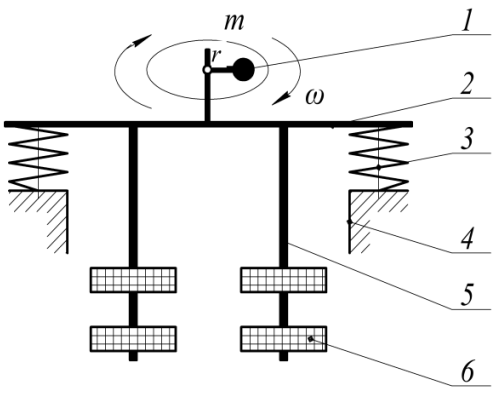
1 – reservoir, 2 – working medium, 3 – support, 4 – hydrodynamic device,
5 – pipeline, 6 – throttling valve

Fig. 2 The actuating mechanisms for the reservoir in the technological system “reservoir with abrasive medium – device with the processed parts”



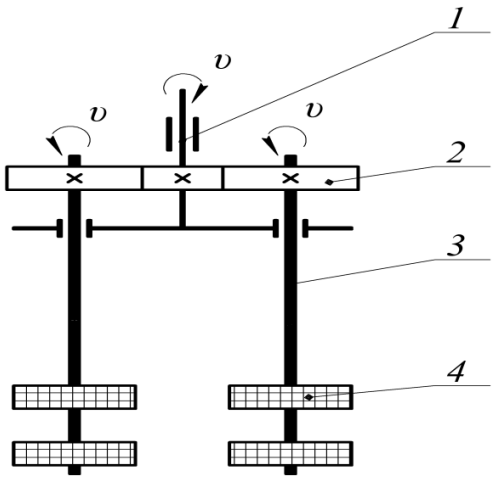
(a)

1 – horizontal vibration exciter,
2 – device, 3 – suspension,
4 – support, 5 – adjusting pins,
6 – processed parts



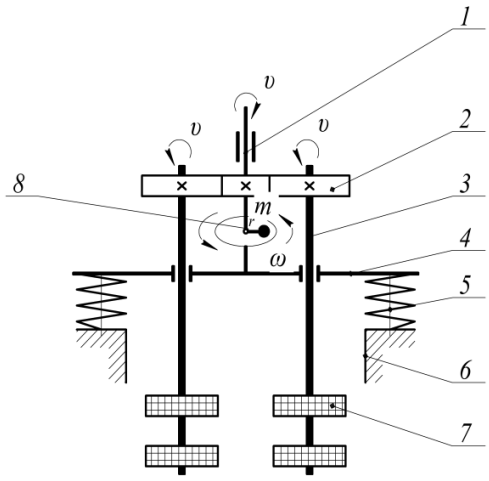
(b)

1 – vertical vibration exciter,
2 – device, 3 – suspension, 4 – support,
5 – adjusting pins, 6 – processed parts



(c)

1 – spindle, 2 – gearing, 3 – adjusting pins,
4 – processed parts



(d)

1 – spindle, 2 – gearing, 3 – adjusting pins,
4 – device, 5 – suspension,
6 – support, 7 – processed parts,
8 – horizontal vibration exciter

Fig. 3 The actuating mechanisms for the device in the technological system “reservoir with abrasive medium – device with processed parts

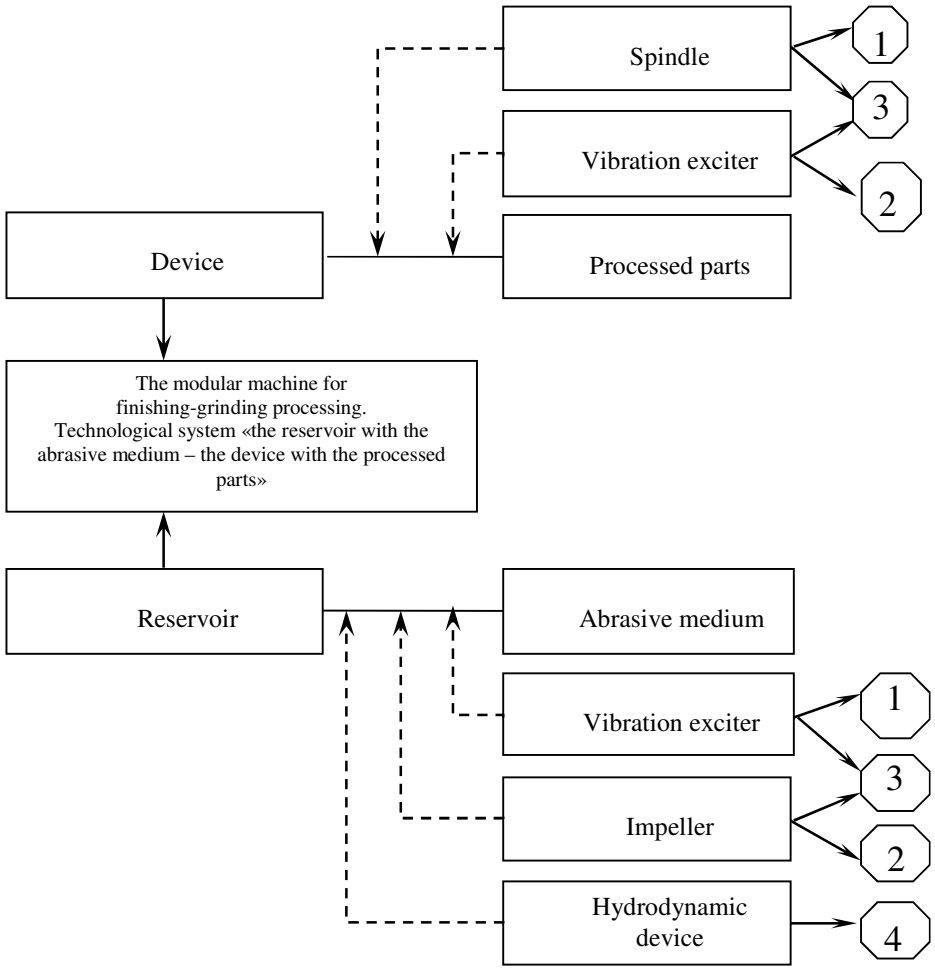


Fig. 4 Variants of project design-technological synthesis of the actuating mechanisms of modular machine and forming of the technological system "reservoir with abrasive medium – device with processed parts"

4. FEATURES OF MODULAR TECHNOLOGIES OF VIBRATION TREATMENT

The development of modular technologies for finishing-grinding treatment, based on dynamic action by the oscillating abrasive medium, results in the creation of new varieties of the vibration treatment method. During the realization of these varieties in obedience to the variants of registration of the technological system "reservoir with abrasive medium – device with processed parts", the power action is formed in the reservoir of modular machine. It creates general circulation through cyclonic motion of the abrasive medium. In this case, the medium freely penetrates to all of almost inaccessible surfaces of the processed parts that results in high efficiency of the vibration treatment.

In the examined varieties of the vibration treatment, executed on the modular machines of dynamic action, an attempt is made to apply as abrasive media fine-dispersed micro-section grinding grains of 200-40 size and grinding powders of 32-16 size, which were moistened by chemically-active solution. The abrasive and metallic granules no larger than 2 mm are also used. Shape-forming properties of such media, providing micro-cutting and elastic-plastic deformation, become apparent at uniform and stable contact with the processed surface of any complication [13, 14].

When vibration processing parts with a complicated and volumetric surface shape, complete use of the cuttings properties of the abrasive medium became possible due to the presence of the actuating mechanisms with a general technical decision in the element base, consisting of fastening the processed parts one by one or as packages, located by rows or roundabout adjusting pins of a multi-seater mechanism, mounted on the vibro-site or on the spindle. This makes possible the immersion into the working zone of the reservoir, filled by the abrasive medium, which is moved under the influence of different schemes of power action.

Additionally, it should be noted that, the accepted setting of the processed parts in the reservoir of the modular machine is instrumental in the origin of the effect of contrary meeting motion of the abrasive medium flows with neutral layers between them. The adjusting pins of the device with the processed parts are placed in these layers, executing the functions of oscillating and revolved deflectors, creating in the abrasive medium an area of cyclonic motion with a complex asymmetrical trajectory and large vibration accelerations, running into 25-30g, where g is the acceleration of terrestrial gravity force.

The velocities of the relative moving and mutual pressure of the abrasive medium and the processed parts increase in the reservoir at presence of the deflectors, that positively affect the treatment of complex-shaped surface sections of the processed parts. Due to the complex use of vibration energy and centrifugal forces, as well as the action forces of stream liquid flows, the imperfect metal layer is removed from these surfaces with a simultaneous diminishing of the roughness.

5. EFFICIENCY OF MODULAR MACHINES AND TECHNOLOGIES OF VIBRATION TREATMENT

The effective use of modular machines and technologies of vibration treatment is provided at the choice of rational combinations of values of the controlled parameters such as amplitude and frequency of oscillations of the vibration exciter, varied within the limits of 0.2-3.0 mm and 30-70 Hz, and also rotational speeds of the impeller and the spindle within the limits of 31.5-1440 rev/min, appointed coming from the requirements of result of executable technological operations.

It should be noted also that, the granulation of the abrasive medium, as well as the efficiency of the action of the applied chemically-active solutions, play a quite significant role in the intensification of the finishing-grinding vibration treatment.

Qualitative and quantitative processing intensification is observed for all investigated new vibration treatment varieties, which are formed from combining the schemes of the power effect on the abrasive medium and the processed parts and materialized on the modular

machines of dynamic action for finishing-grinding treatment in oscillating abrasive media. The intensity of the specific metal output in the experimental vibration treatment in obedience to offered technical innovations increased by 1.8-2.4 times in comparison with conventional vibration processing equipment and technologies [3].

6. CONCLUSIONS

Summarising the remarks listed above, it may be concluded that, our investigations provide a basis for further scientific studies and technological design of new modular machines and technologies of finishing-grinding treatment, based on a project design-technological synthesis of concerted autonomously controlled actuating mechanisms in accordance with the principle of combining various schemes of power effecting the abrasive medium and the processed parts. The application of the power action schemes is determined by the required final outcome of the finishing-grinding treatment.

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